IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel W. A. DREW EDMONDSON, in his capacity as ATTORNEY GENERAL OF THE STATE OF OKLAHOMA, and OKLAHOMA SECRETARY OF THE ENVIRONMENT C. MILES TOLBERT, in his capacity as the TRUSTEE FOR NATURAL RESOURCES FOR THE STATE OF OKLAHOMA, Plaintiff, V. TYSON FOODS, TYSON POULTRY, INC., TYSON CHICKEN, INC., COBB-VANTRESS, INC., AVIAGEN, INC., CAL-MAINE FOODS, INC., CAL-MAINE FARMS, INC., CARGILL, INC., CARGILL TURKEY PRODUCTS, LLC, GEORGE'S, INC., GEORGE'S FARMS, INC., PETERSON FARMS, INC., SIMMONS FOODS, INC., AND WILLOWBROOK FOODS, INC. Defendants	§ §	CASE NO. 05-CV-329-GFK-SAJ

DECLARATION OF CHARLES B ANDREWS, Ph.D.

The undersigned, Charles B. Andrews, states:

1) I am President of S.S. Papadopulos & Associates, Inc. (SSP&A), a water-resource and environmental consulting firm based in Bethesda, Maryland. I received a Ph.D. in geology from the University of Wisconsin, and I have over twenty-five years of professional experience in groundwater consulting. I have worked on and evaluated groundwater conditions at many hundreds of sites in the United States. I have analyzed groundwater flow conditions at many sites in karstic terrain and have conducted dye-tracer tests to analyze flow in karst aquifers.

2) My education, research, and professional experience are in the fields of geology, hydrogeology, and water resources. My curriculum vitae including a list of publications, and trial and deposition experience is included in the Attachment. My

expertise includes the evaluation of the origin, distribution, fate, and transport of contaminants in the environment and I have published numerous technical papers on these topics. I am a registered professional geologist in the states of California, Alabama, and Georgia. I am an associate editor of the journal *Ground Water*. I have served on a number of national committees including the National Research Council committees on Alternatives for Groundwater Cleanup and Groundwater Models: Scientific and Regulatory Applications. I just completed a three-year term as chair of the Montgomery County, Maryland, Water Quality Advisory Group.

3) I was retained by the Defendants to form and render opinions on the claim of substantial and imminent endangerment of human health filed by the State of Oklahoma as elements of that claim relate to my areas of expertise. I have relied upon extensive education, training, and experience in the field of hydrology as well as the reports and documents provided by the Plaintiffs in formulating the opinions expressed in this report. The documents upon which I relied are the types of documents typically used by hydrology experts to evaluate the nature, extent, timing and progression of contaminants in groundwater. I visited the Illinois River watershed, including a visit to an active poultry house, in January 2008. I was assisted in my work by the professional staff at S.S. Papadopulos & Associates, Inc.

4) Based on the data and information that were reviewed and my experience and education, the following opinions were reached:

   a) The percentage of domestic wells, based on Plaintiff's data, in the Illinois River watershed with bacterial contamination is less than that found in other karstic aquifers in the United States and the percentage of domestic wells in the Illinois River watershed with bacterial contamination has not increased over the past forty years;

   b) Bacterial contamination of groundwater is most probably from local sources as groundwater flow is localized with recharge occurring in upland areas and discharge occurring to nearby streams;

   c) Groundwater samples from domestic wells in which enteric bacteria have been detected do not contain concentrations of arsenic, copper, zinc, and phosphorous, which have been identified as poultry fingerprint compounds by the Plaintiff's experts, at greater concentrations than domestic wells in which enteric bacteria have not been detected;

   d) Septic tanks, which are used by about 73,000 residents in the Illinois River watershed, are a significant source of localized groundwater contamination;

   e) During periods when the flow of the Illinois River is maintained by groundwater discharge and sewage treatment plant discharges, bacterial standards for contact recreation are generally not exceeded. This indicates that there is not widespread bacterial contamination of groundwater.

f) Groundwater samples from unconsolidated materials generally are not representative of water quality within the shallow bedrock aquifer which is referred to as the Springfield Plateau Aquifer and locally as the Boone-St. Joe Aquifer.

g) The shallow bedrock aquifer is generally hydraulically separated from the deeper Ozark Aquifer by the Ozark Confining Unit, known locally as the Chattanooga Shale.

h) Adhering to best management practices, as adopted in nutrient management plans for fields in Oklahoma and Arkansas, significantly reduces the potential for bacterial contamination of groundwater from the application of poultry litter.

i) Numerous processes active in the subsurface in the karstic terrain of the Illinois River watershed, including attachment, predation, filtration, and die off, significantly attenuate bacteria as they migrate in the subsurface with groundwater from recharge areas to discharge areas.

j) The presence of indicator bacteria in groundwater, such as fecal coliform, Escherichia coli, and Enterococci, does not equate to an imminent threat to human health and the environment.

k) A cessation of the application of poultry litter to lands in the Illinois River watershed will not result in a significant change in the percentage of domestic wells in which water samples test positive for the presence of enteric bacteria, nor will it result in a significant change in bacteria concentrations in the Illinois River during base flow conditions (times when the flow of the river is maintained by groundwater discharge and sewage treatment plant discharges).

The foundation for these opinions is described below.

5) Bacteria contamination is common in rural domestic wells in the United States. For example, in a national survey of microbial contamination, in which samples were taken from 347 wells, 30 percent of all wells tested positive for fecal-indicator bacteria.[1] In Pennsylvania it was concluded that 53 percent of water samples from wells had an exceedance of a microbial standard.[2] Likewise, in the Lower Susquehanna River Basin in Pennsylvania and Maryland, it was reported that 70 percent of groundwater well samples tested positive for total coliform and 25 percent tested positive for fecal coliform.[3] In karst aquifers the incidence of enteric bacteria

[1] Embrey, S.S. and D.L. Runkle, 2006. Microbial quality of the Nation's ground-water resources, 1993-2004.

[2] D. Low and D. Chichester, 2006. Ground-Water Quality in Pennsylvania – A Compilation of Computerized [electronic] Databases, 1979-2004. U.S. Geological Survey, Data Series 150.

[3] Bickford, T., B. Lindsey, and M. Beaver, 1996. Bacteriological Quality of Ground Water Used for Household Supply, Lower Susquehanna River Basin, Pennsylvania and Maryland. U.S. Geological Survey Water-Resources Investigation Report 96-4212.

is high; in a study in Berkeley County, West Virginia, in 2000, approximately 33 percent of the wells samples tested positive for Escherichia coli,[4] and in a study in the Upper Tennessee River basin Escherichia coli was detected in 30 percent of the wells sampled.[5] In a detailed study of 25 domestic wells completed in the shallow karstic Niagara Dolomite in Door County, Wisconsin, Escherichia coli was detected in 28 percent of the wells tested.[6] In the Illinois River watershed, in domestic wells tested by the Plaintiff's in 2006 and 2007, fecal coliform and Escherichia coli were detected in less than 20 percent of the wells.

6) Many groundwater quality investigations have been conducted in the Illinois River watershed over the past fifty years. In a 1972 study in which 50 wells in Benton and Washington Counties were sampled, 72 percent of the wells tested positive for fecal coliform.[7] In a 1975 study in Washington County, in which water samples from 36 wells were analyzed for bacteria, fecal coliform was detected in 25 wells (70 percent).[8] A study of groundwater wells in Benton County, Arkansas, in 1980 reported that total coliform was detected in 67 percent of water samples and fecal streptococcus was detected in 51 percent of the water samples.[9] The results of these studies do not support the conclusions of the Plaintiff's experts that the percentage of domestic wells in the Illinois River watershed with bacterial contamination has been increasing through time;

7) The Springfield Plateau Aquifer is an unconfined aquifer; that is, the water table generally occurs within the aquifer unit. Groundwater discharge from the Springfield Plateau Aquifer sustains the flow of the many perennial creeks and streams within the Illinois River basin. Many of the creeks and streams are aligned with fault/fracture zones, and thus these zones have an influence on the direction of groundwater flow. Groundwater recharge occurs in the upland areas and in general the distance from recharge area to discharge area in on the order of a few miles or less. Thus most groundwater is derived from local recharge. Studies by the U.S. Geological Survey have indicated that the minimum average age of groundwater is on the order of 2 to 6 years; that is, it takes on average about 4 years for a particle of water to flow from the recharge area to the discharge area.[10]

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[4] Mathes, M., D. Stoechel, and K. Hyer, 2002. Comparison of Methods to Source Track Bacteria in Ground Water in Karst Areas of Berkeley County, West Virginia. U.S. Geological Survey Karst Interest Group Proceedings, Shepherdstown, West Virginia, August 20-22.

[5] Gregory C. Johnson (1997). Water Quality of Springs in the Valley and Ridge Physiographic Province in the Upper Tennessee River Basin. USGS. Water-Resources Investigations Report 02-4180.

[6] Braatz, L.A., 2004. A Study of Fecal Indicators and Other Factors Impacting Water Quality in Private Wells in Door County, Wisconsin. M.S. Thesis, University of Wisconsin-Green Bay.

[7] Kenner, R. 1972. Septic Tank Contamination of Groundwater. University of Arkansas at Fayetteville, 23 pp. as reported in Arkansas Academy of Science Proceedings, Vol. XXXIV, 1980 page 42.

[8] Coughlin, T.L., 1975. Geologic and Environmental Factors Affecting Groundwater Chemistry in North-Central Washington, County, Arkansas. M.S. Thesis, University of Arkansas at Fayetteville, 130 pp.

[9] Ogden, A., 1980. Hydrogeologic and geochemical investigation of the Boone-St. Joe Limestone Aquifer in Benton, County, Arkansas. Arkansas Water Resources Research Center, University of Arkansas, Fayetteville, Arkansas, Publication No. 68.

[10] Adamski, J., 1999, Geochemistry of the Springfield Plateau Aquifer of the Ozark Plateaus Province in Arkansas, Kansas, Missouri, and Oklahoma, USA. Hydrogeological Processes, v. 14, pp 849-866.

8) The domestic wells in the Illinois River watershed sampled by the Plaintiffs were subdivided into two groups for purposes of analyzing the water-quality data from the wells; wells in which fecal coliform were detected and wells in which fecal coliform were not detected. The median dissolved concentrations of the compounds alleged by the Plaintiff's experts to fingerprint poultry waste, arsenic, copper, zinc, and phosphorous were not elevated in the wells with fecal coliform relative to wells with no fecal coliform. If elevated concentrations of these alleged fingerprint compounds, relative to wells not impacted by poultry waste, are a reliable indicator of groundwater impacted from poultry waste, then there is no evidence that groundwater has been so impacted.

9) Septic tanks are a probable source of enteric bacteria in domestic wells. Septic tanks are located, in general, in proximity to domestic wells and are constructed in a manner that infiltrates the waste several feet below the land surface. In areas with shallow soils this results in an effective short-circuiting through the soil horizons. Studies report that many septic systems are inadequately constructed and/or located and that many septic systems malfunction. The Illinois River Basin Plan notes that it is likely that as many as 75 percent of the on-site waste disposal systems are inadequately constructed or located.[11] A survey of septic systems in Tontitown and Highfill, Arkansas, found that most septic systems were not permitted and that many had some type of problem.[12] Numerous studies have indicated septic tanks as the likely source of enteric bacteria in water samples from domestic wells. In a detailed study of sources of contamination in wells and springs in the Springfield Plateau aquifer in Delaware County, Oklahoma, caffeine was detected in many springs and in the one well in which fecal coliform were detected.[13] A study of groundwater conditions in Benton County, Arkansas, concluded that the data suggests that many wells are contaminated by septic tank systems, surface runoff, or both.[14]

10) The Plaintiff's experts have failed to demonstrate a correlation between poultry litter application and contamination of domestic wells. Similarly, a lack of correlation between presence of enteric bacteria in water samples from wells and distance to fields where poultry litter was applied was found in a detailed study conducted by the U.S. Geological Survey at a site overlying the Springfield Plateau aquifer in

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[11] Haraughty, S., 1999. Comprehensive Basin Management Plan for the Illinois River Basin in Oklahoma. Oklahoma Conservation Commission, Page 94.

[12] Engineering Services, Inc., 2004. Septic Tank Survey of Tontitown, Arkansas and Highfill, Arkansas for Osage Basin Wastewater District.

[13] Schlottmann, J.L, R. Tanner, and M. Samadpour, 2000. Reconnaissance of the Hydrology, Water Quality, and Sources of Bacterial and Nutrient Contamination in the Ozark Plateaus Aquifer System and Cave Springs Branch of Honey Creek, Delaware County, Oklahoma, March 1999-March 2000. U.S. Geological Survey Water-Resources Investigations Report 00-4210.

[14] Cox, G., A. Ogden and G. Slavik, 1980. Contamination of Boone-St. Joe Limestone Groundwater by Septic Tanks and Chicken Houses. Arkansas Academy of Science Proceedings, Vol. XXXIV, 1980.

southwest Missouri.[15] A similar lack of correlation was noted in a study in Benton County, Arkansas.[16]

11) Groundwater discharge sustains the flow of the Illinois River during periods between major storms when there is no significant surface water runoff. These periods are referred to as base flow conditions. An analysis of the bacteria data collected on the Illinois River from the mid-1990's to the present shows that the bacteria standards for contact recreational uses are generally not exceeded during base flow conditions. This indicates that the groundwater discharging to the streams during base flow conditions does not contain bacteria at concentrations above the standards.

12) The water table occurs in some areas within the unconsolidated material overlying the bedrock. The groundwater samples collected by the Plaintiff's experts using the Geoprobe method collected groundwater from the unconsolidated material. Bacteria concentrations in this shallow water are not indicative of concentrations that occur, or potentially can occur, in the deeper bedrock groundwater that is tapped as a water source for domestic supply. Numerous processes attenuate bacteria as the groundwater migrates from the water table to deeper portions of the aquifer. These processes include attachment, filtration, predation and die off. In the karstic Springfield Plateau aquifers, the degree of attenuation can vary significantly depending upon the characteristics of the pathways through which the groundwater migrates.

13) The nutrient management plans developed to comply with regulations in Oklahoma and Arkansas specify the use of best management practices to minimize the potential for migration of bacteria from fields to groundwater and surface water. Adhering to these practices, including proper application rates, timing of application, and avoidance of spreading in buffer zones will significantly reduce the potential for contamination of groundwater and surface water with bacteria.

14) The presence of indicator bacteria does not equate to an imminent threat to human health. Indicator bacteria, as the name implies, are merely bacteria that may indicate the presence of pathogenic bacteria and/or viruses. Two specific genera of pathogenic bacteria were identified by the Plaintiff's experts as being associated with poultry litter; Salmonella and Campylobacter. Groundwater samples were only tested for Salmonella. Salmonella was only detected in only one of the wells sampled in the Illinois River watershed, and in this well the concentration was reported at the detection limit of 2 MPN/100 ml.

15) The Plaintiff's groundwater data does not support the conclusion that there is widespread contamination of groundwater with fecal bacteria. Fecal coliform was

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[15] Mugel, D., Ground-water Quality and Effects of Poultry Confined Animal Feeding Operations on Shallow Groundwater, Upper Shoal Creek Basin, Southwest Missouri. U.S. Geological Survey Water-Resource Investigation Report 2002-4125.

[16] Kenner, R. 1972. Septic Tank Contamination of Groundwater. University of Arkansas at Fayetteville, 23 pp. as reported in Arkansas Academy of Science Proceedings, Vol. XXXIV, 1980 page 42.

detected in less than twenty percent of the residential wells that were sampled. This frequency of detection is lower than that found in other karst aquifers in the United States and is most probably from localized sources of contamination, including septic tanks. Therefore, the cessation of the application of poultry litter to lands in the Illinois River watershed will not result in a significant change in the percentage of wells in which water samples test positive for the presence of enteric bacteria, nor will in result in significant change in bacteria concentrations in Illinois River during base flow conditions.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Charles B. Andrews

Charles B. Andrews, Ph. D.

2-08-2008

Date

Attachment A

Dr. Andrews' Curriculum Vitae and Rate of Compensation

CHARLES B. ANDREWS

Groundwater Hydrologist

EDUCATION

PhD Geology, 1978, University of Wisconsin, Madison, Wisconsin
MS Geology, 1976, University of Wisconsin, Madison, Wisconsin
MS Water Resources, 1974, University of Wisconsin, Madison, Wisconsin
BA Geology, 1973, Carleton College, Northfield, Minnesota

American University of Beirut, Beirut, Lebanon, 1971-1972

REGISTRATIONS

Registered Geologist California No. 3853
Georgia PG001689
Alabama No. 1175

PROFESSIONAL HISTORY

S.S. Papadopulos & Associates, Inc., Bethesda, Maryland
President, 1994-present
Principal Hydrogeologist, 1984-present
Woodward-Clyde Consultants, San Francisco and Walnut Creek, California
Hydrogeologist and head of Groundwater Section, 1980-1984
Northern Cheyenne Indian Tribe, Lame Deer, Montana
Scientist, 1978-1980
Wisconsin State Government, Department of Justice and Department of Natural Resources, Madison, Wisconsin
Consultant, 1977-1978
University of Wisconsin, Department of Geology & Geophysics, Madison, Wisconsin
Research Assistant, 1975-1978
University of Wisconsin, Department of Water Resources, Madison, Wisconsin
Researcher, 1974-1975

SUMMARY OF QUALIFICATIONS

Dr. Andrews is nationally known for his creative solutions to difficult groundwater problems. His areas of expertise include the assessment and remediation of contaminated sites, formulation of groundwater projects, assessment of groundwater flow and quality conditions at hazardous waste sites, design of groundwater remediation systems, and development of new and modification of off-the-shelf numerical simulation models for adaptation to specific field projects. He has provided technical guidance to significant water-rights litigation. Dr. Andrews is a frequently requested member of groundwater advisory panels for the evaluation of state-of-the-art hydrology and for pioneering research and evaluation of contaminant transport in the subsurface. He is the author and co-author of numerous publications on modeling of groundwater flow and transport of chemical constituents, and the use of analytical models in identifying appropriate remediation alternatives for a site.

As President of S.S. Papadopulos & Associates, Inc., Dr. Andrews overviews and serves as technical advisor on all projects. S.S. Papadopulos & Associates, Inc. is a 60-person environmental consulting firm that specializes in the assessment and remediation of contaminated sites and groundwater problem solving.

APPOINTMENTS

Board of Visitors, Department of Geology, University of Wisconsin, 2005-present
Water-Quality Advisory Group, Chairman, Montgomery County, Maryland, 2003-present

CHARLES B. ANDREWS

Groundwater Hydrologist

APPOINTMENTS — *continued*

National Ground Water Association *Group 2020,* April 2001-present
Associate Editor, *Ground Water,* 1998-present
Board of Directors of the Association of Groundwater Scientists and Engineers Division of the National Ground Water Association, 1997-2001
National Research Council Committee on Groundwater Cleanup Alternatives, National Academy of Sciences, 1991-1994
National Research Council Committee on Groundwater Modeling Assessment, National Academy of Sciences, 1987-1988

REPRESENTATIVE PROJECT EXPERIENCE

S.S. Papadopulos & Associates, Inc., Bethesda, Maryland

Dr. Andrews is an experienced project designer and manager who has the special ability to present practical solutions for complex hydrogeologic issues. He has developed and applied analytical and numerical models in the evaluation of groundwater flow, contaminant migration, and heat-transport. He has designed remediation plans for mitigating soil and groundwater contamination, and has been a groundwater expert in a number of legal matters. Specific project experience:

- Leads the groundwater modeling effort for design of remedial alternatives for Onondaga Lake, Syracuse, New York. This lake is reputed to be the most contaminated lake in the United States and remediation is projected to cost several hundreds of millions of dollars. In this role he interacts frequently with and has made many presentations to the New York State Department of Environmental Conservation.
- Conducted a detailed laboratory evaluation of analytical methods used to analyze for phenols in water samples. Determined that certain analytical methods are prone to false positive due to reactions with dissolved natural organic matter during the analytical procedure. Identified the probable reaction pathways for the reactions that create phenols from the dissolved organic matter.
- Conducted a detailed field and laboratory evaluation of the leachability of PCBs from contaminated soils from a large industrial facility in Georgia. Developed innovative methods to distinguish dissolved and particulate phase PCBs in leachate from batch tests.
- Participated as a technical expert for a major pipeline company in year-long Consent Decree negotiations with the U.S. Department of Justice on soil and groundwater contamination issues at 30 compressor station sites. Developed a comprehensive framework, which was incorporated in the Consent Decree, for efficient, cost-effective investigation and remediation of compressor stations.
- Provided groundwater consulting services for the identification and development of spring water sources for a major bottled water company in Michigan. This work involved development of groundwater models to determine potential production rates, optimal pumping rates and locations, and environmental effects of water production. In addition, developed long-term monitoring plans and was an expert witness in litigation related to development and operation of spring water sources.

CHARLES B. ANDREWS

Groundwater Hydrologist

REPRESENTATIVE PROJECT EXPERIENCE — *continued*

- Served on a review panel for Hanford site-wide groundwater flow and transport model, 1989-2001; and developed a groundwater model of the A- and M- areas at the Savannah River Site, 1985-1986.
- Directed a study to evaluate the mobility and fate of polychlorinated biphenyl compounds (PCBs) in the subsurface for over 30 contaminated sites. These studies involved laboratory and field experiments to investigate the interactions between PCBs and the subsurface materials, and to investigate the potential degradation of PCBs in the subsurface. Long-term monitoring was selected as the appropriate remedial action at all the sites.
- Evaluated the long-term availability of groundwater and the associated water-quality problems of the Hueco Bolson and the Mesilla Basins, large regional aquifers in southern New Mexico, for the Attorney General of New Mexico. Served as an expert witness in litigation involving the proposed development of large water supplies from these basins.
- Managed remediation activities, including remedial investigations, feasibility studies, remedial design and implementation, for industrial sites in California and New Jersey that are extensively contaminated with arsenic and associated heavy metals. Several of these investigations involved the evaluation of geochemical parameters that govern arsenic mobility in the subsurface and groundwater/surface-water interactions.

Woodward-Clyde Consultants, San Francisco and Walnut Creek, California

Senior Project Manager of the 15-person Ground-Water Group: Responsible for water-resource business development, technical review of all water-resource projects, and staff administration. Served as Project Manager and Hydrology Task Leader on projects such as the development of groundwater flow models of Madison Aquifer in Wyoming and the San Juan Basin in New Mexico; analysis of reservoir-induced seismicity at the Aswan Dam; and development of a groundwater model and remediation plan for a 12,000-acre site having 200 major source areas. Responsible for developing the firm's state-of-the-practice capabilities in quantitative hydrology.

Northern Cheyenne Indian Tribe, Lame Deer, Montana

Directed and helped establish a comprehensive surface-water and groundwater monitoring program, and established and managed the tribal computer system. Trained tribal members in the operation and management of the hydrologic monitoring system and the computer system. Participated in numerous administrative and legislative proceedings as an advocate for tribal management of the reservation's natural resources.

Wisconsin State Government, Department of Justice and Department of Natural Resources, Madison, Wisconsin

Served as an expert witness for several judicial and administrative proceedings on cases involving groundwater contamination and wetland drainage.

CHARLES B. ANDREWS

Groundwater Hydrologist

REPRESENTATIVE PROJECT EXPERIENCE — *continued*

University of Wisconsin, Department of Geology and Geophysics, Madison, Wisconsin

Researched the impacts of heated-water seepage from a power plant cooling lake. Developed a finite-element computer code to simulate water and heat transfer in shallow unconfined aquifers, and designed and maintained an extensive field monitoring program to collect the data needed for model verification.

University of Wisconsin, Department of Water Resources, Madison, Wisconsin

Conducted research that was funded by the U.S. Environmental Protection Agency - Denver, on the impact of oil shale development to the groundwater and surface-water resources of northwestern Colorado.

PROFESSIONAL SOCIETIES

American Geophysical Union
National Ground Water Association
American Association for the Advancement of Science
Geological Society of America
American Water Works Association

PUBLICATIONS

Andrews, C.B., 2008. Review of "Effective Groundwater Model Calibration: With Analysis of Data, Sensitivities, Predictions, and Uncertainty": *Ground Water*. 46, no. 1: 5.

Karanovic, M., C.J. Neville, and C.B. Andrews. 2007. BIOSCREEN-AT: BIOSCREEN with an Exact Analytical Solution: *Ground Water*. 45, no. 2: 242-245.

Andrews, C.B., and G. Swenson. 2006. Simulation of Brine Movement into Onondaga Lake. MODFLOW and More 2006, Managing Ground-Water Systems, International Ground Water Modeling Center, Colorado School of Mines Golden, Colorado, May 22-24, 2006. Vol. 2. 480-483.

Neville, C.J., and C.B. Andrews. 2006. Containment Criterion for Contaminant Isolation by Cutoff Walls: *Ground Water*. 44, no. 5, September-October: 682-686.

Spiliotopoulos, A.A., and C.B. Andrews. 2006. Analysis of Aquifer Test Data – MODFLOW and PEST. MODFLOW and More 2006, Managing Ground-Water Systems, International Ground Water Modeling Center, Colorado School of Mines, Golden, Colorado, May 22-24, 2006. Vol. 2. 569-573.

Vlassopoulos, D., N. Rivera, P.A. O'Day, M.T. Rafferty, and C.B. Andrews. 2005. Arsenic Removal by Zerovalent Iron: A Field Study of Rates, Mechanisms, and Long-Term Performance. In *Advances in Arsenic Research: Integration of Experimental and Observational Studies and Implications for Mitigation*. O'Day, P.A., D. Vlassopoulos, X. Meng, and L.G. Benning, editors. ACS Symposium Series Vol. 915. Washington, DC: American Chemical Society. 344-360.

Andrews, C., and C. Neville. 2003. Ground Water Flow in a Desert Basin: Challenges of Simulating Transport of Dissolved Chromium: *Ground Water*. 41, no. 2: 219-226.

CHARLES B. ANDREWS

Groundwater Hydrologist

PUBLICATIONS
— continued

Rafferty, M.T., C.B. Andrews, D. Vlassopoulos, D. Sorel, and K.M. Binard. 2003. Remediation of an Arsenic Contaminated Site. Presented at the 226th American Chemical Society National Meeting, September 7-11, 2003, New York City, New York.

Vlassopoulos, D., C.B. Andrews, M. Rafferty, P.A. O'Day, and N.A. Rivera Jr. 2003. In Situ Arsenic Removal by Zero Valent Iron: An Accelerated Pilot Test Simulating Long-Term Permeable Reactive Barrier Performance. Presented at the 226th American Chemical Society National Meeting, September 7-11, 2003, New York City, New York.

Sorel, D., C.J. Neville, M.T. Rafferty, K. Chiang, and C.B. Andrews. 2002. Hydraulic Containment Using Phytoremediation and a Barrier Wall to Prevent Arsenic Migration. In *Proceedings of the Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 20-23, 2002, Monterey, California*. Gavaskar, A.R., and A.S.C. Chen, editors. Battelle Press.

Vlassopoulos, D., J. Pochatila, A. Lundquist, C.B. Andrews, M.T. Rafferty, K. Chiang, D. Sorel, and N.P. Nikolaidis. 2002. An Elemental Iron Reactor for Arsenic Removal from Groundwater. In *Proceedings of the Third International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 20-23, 2002, Monterey, California*. Gavaskar, A.R., and A.S.C. Chen, editors. Battelle Press.

Andrews, C., and C. Neville. 2001. Groundwater Flow in a Desert Basin: Complexity and Controversy. Proceedings of MODFLOW 2001 and Other Modeling Odysseys, September 11-14, 2001, International Groundwater Modeling Center, Golden, Colorado. 770-775.

Andrews, C.B. 2000. The Great American Experiment: Pump-and-Treat for Groundwater Cleanup. Proceedings of the International Symposium on Groundwater Contamination, Japanese Association of Groundwater Hydrology, Tokyo, Japan. June 26.

Andrews, C.B. 2000. The Meaning of Success in Assessing Groundwater Remediation. Western Pacific Geophysics Meeting, June 27-30, 2000, Tokyo, Japan. In *Eos*. 81, no. 22, May 30.

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Lolcama, J.L., and C.B. Andrews. 1999. Catastrophic Flooding of a Quarry in Karstified Dolomite (Abstract). NGWA National Convention and Exposition, December 3-6, 1999, Nashville, Tennessee. In *Ground Water Supply Issues in*

CHARLES B. ANDREWS

PUBLICATIONS
— continued

the Next Century, 1999 Abstract Book. National Groundwater Association, editor. Nashville, Tennessee: National Groundwater Association.

Vlassopoulos, D., C. Andrews, R. Hennet, and S. Macko. 1999. Natural Immobilization of Arsenic in the Shallow Groundwater of a Tidal Marsh, San Francisco Bay. Presented at the The American Geophysical Union 1999 Spring Meeting, May 31-June 4, Boston, Massachusetts.

Andrews, C.B. 1998. MTBE: A Long-Term Threat to Ground Water Quality: *Ground Water*. 36, no. 5: 705-706.

Hennet, R., D.A. Carleton, S.A. Macko, and C.B. Andrews. 1997. Environmental Applications of Carbon, Nitrogen, and Sulfur Stable Isotope Data: Case Studies (abstract). Geological Society of America, Annual Meeting, Salt Lake City, Utah, November 1997. (invited speaker).

Zhang, Y., C. Zheng, C.J. Neville, and C.B. Andrews. 1996. ModIME User's Guide: An Integrated Modeling Environment for MODFLOW, PATH3D, and MT3D. Version 1.1. Bethesda, MD: S.S. Papadopulos & Associates, Inc.

Larson, S.P., C.B. Andrews, and C.J. Neville. 1995. Parameter Estimation in Groundwater Modeling: Research, Development, and Application (Abstract). American Geophysical Union (AGU) Spring Meeting, Baltimore, May 30 - June 2, 1995, Hydrology Sessions. S145, Abstract H51C-02 0835h.

Andrews C.B. (co-author). 1994. Chapter 3: Performance of Conventional Pump-and-Treat Systems and Chapter 5: Characterizing Sites for Ground Water Cleanup. In *Alternative Ground Water Cleanup.* Washington, DC: National Academy Press.

Hennet, R.J.-C., and C.B. Andrews. 1993. PCB Congeners as Tracers for Colloid Transport in the Subsurface--A Conceptual Approach. In *Manipulation of Groundwater Colloids for Environmental Restoration.* Ann Arbor, MI: Lewis Publishers. 241-246.

Zheng, C., G.D. Bennett, and C.B. Andrews. 1992. Reply to the Preceding "Discussion by Robert D. McCaleb of 'Analysis of Ground-Water Remedial Alternatives at a Superfund Site' ": *Ground Water*. 30, no. 3: 440-442.

Zheng, C., G.D. Bennett, and C.B. Andrews. 1991. Analysis of Ground-Water Remedial Alternatives at a Superfund Site: *Ground Water*. 29, no. 6: 838-848.

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DEPOSITION AND TESTIMONY EXPERIENCE

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Rate of Compensation

Dr. Andrews' rate of compensation is $232.00 per hour.